Semi-annual Status Report

to

National Aeronautics and Space Administration

from

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on

"A RESEARCH IN SUPPORT OF NASA'S SPACE SCIENCE"

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for the period

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F. S. Johnson
Principal Investigator

August 21, 1974

INTRODUCTION

This grant is very important to the space research activities at The University of Texas at Dallas as it is used to develop instrumentation for anticipated missions, to increase the productivity of past measurements through data analysis beyond that funded on a project basis, and to maintain capability for engaging in space projects when gaps occur between funded projects. It is especially helpful to have maximum flexibility in shifting support among activities in the above categories, or among activities within a single category, depending upon need and perceived opportunity. The funds contribute, not only to immediate scientific return, but to the maintenance of capability for future productive efforts in space science.

The grant has also been used to help secure a mini computer for processing of space data and for some scientific computing on space science problems. Its size is well matched to the data processing problems and it provides a much more economical means of processing space data than has otherwise been available to us. As indicated in more detail below in the discussion of ISIS data analysis, it now is possible to contemplate the complete processing of all data from many projects, including its transferal as desired to other scientists for coordinated investigations using data from different sources.

The various projects which have been supported on this grant during the past six months are discussed below.

MINIATURE MASS SPECTROMETER

John H. Hoffman

Several current NASA programs such as Pioneer Venus and Atmospheric Explorer require very light weight mass spectrometers to measure both neutral and ion composition. Such an instrument has been designed and built. The analyzer itself including magnet, ion source and collector systems weighs less than 2 Kilograms. It covers the mass range from 1 to 64 amu in three sections; that is 1 to 4, 4 to 16 and 16 to 64. The dynamic range of the instrument is from 10^{-1} to 10^{5} ions cm^{-3}. The first model of this instrument was tested in a rocket program called the Equion program. This consisted of a Black Brandt rocket which was flown from the Peruvian test range in Spring, 1974. The attached photograph (Figure 1) shows the instrument mounted in the rocket payload at the top of the package. In this configuration the entire package including the electronics in a hermetically sealed box weighed 10.5 Kilograms. It consumed 2.3 watts of power.

The performance of an instrument this size is excellent. Figure 2 shows a mass spectrum obtained from this instrument. The mass resolution on the low and mid mass channels is such that well resolved flat top peaks are exhibited throughout the entire ranges. The high mass channel resolution is sufficient to resolve peaks (1% contribution from adjacent peaks) out to mass 55 amu.

A second version of this instrument has been designed and constructed for test in the Atmospheric Explorer-E mission. This launch is expected to

occur in the summer of 1975. The instrument consists of a dual ion-neutral mass spectrometer with a retarding voltage analyzer built into the ion source. The significance of this retarding voltage analyzer is that it can eliminate gases arising from the instrument or the spacecraft or from molecular gas species which have collided with the spacecraft from being analyzed; it passes only those gas molecules having the ram energy due to the motion of the spacecraft through the medium. This instrumentwwill be tested on the AE-E flight and may well serve to provide data on the atomic and molecular oxygen as well as the nitric oxide and atomic nitrogen contents of the earth's atmosphere. Its major impact, though, will be in planetary and cometary missions in the future. By conducting this test in earth orbit where data rates are high and command capability excellent, an in-flight study will be made of the adjustments of all the various parameters in the ion source, particularly with reference to the RV or fly-through mode. Likewise, a study will be made of the feasibility of using a single mass spectrometer to measure both ion and neutral composition; this may permit a large saving in weight and volume for planetary and cometary missions in the future.

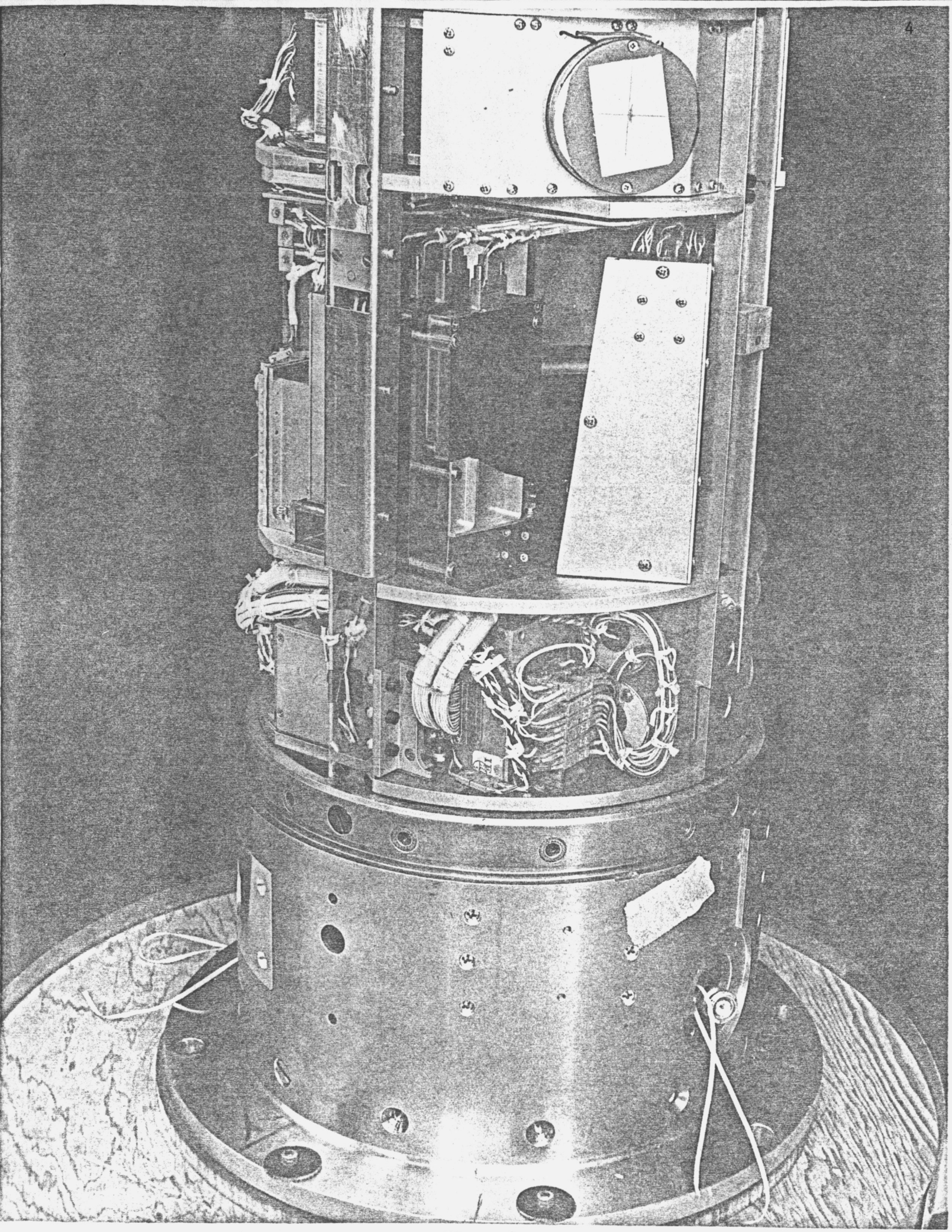

Figure 1

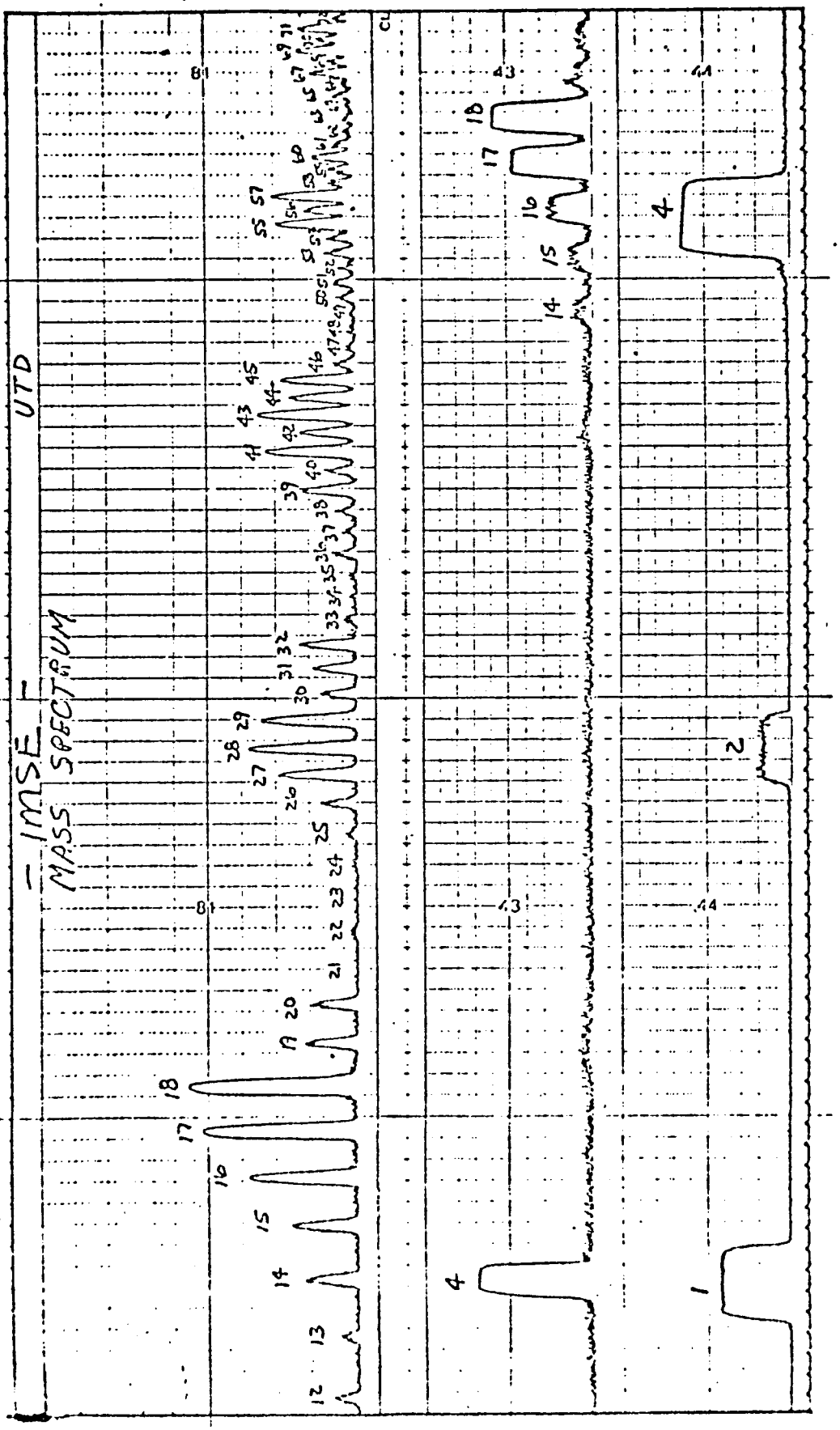

Figure 2

SOFT PARTICLE SPECTROMETER

W. J. Heikkila and J. D. Winningham

We have redesigned the soft particle spectrometer that obtained so many useful data in the ISIS-1 and -2 satellites, making use of COSMOS devices which were not available when the original instruments were built. The next spectrometer is more compact, by more than a factor of two in volume and weight, and it also consumes less power. It is eminently suitable for rocket and satellite applications.

This new instrument was flown in two separate rocket programs during this reporting period. The first was the EQUION project, funded by NASA, the National Science Foundation, the U. S. Air Force, and the Aerospace Corporation. The rocket, a Black Brant 4, was launched on March 28, 1974, from a new range built by the Peruvian Government on the coast at Chilca, south of Lima. The payload included a number of instruments from UTD and the Aerospace Corporation for studies of the equatorial ionosphere. The support provided under this grant was important for the execution of this project, since the scientific and engineering team was otherwise without support because of the decreased funding under other grants and contracts. The data that were obtained are of high quality and extremely interesting, so much so that we have entered into discussions with Aerospace Corporation and NASA personnel concerning the possibility of a second rocket launching with some additional instruments.

Two additional SPS (soft particle spectrometer) instruments of the same design were flown in on July 2 and 8, 1974, on Nike Tomahawk rockets instrumented by the Danish Space Research Institute and the Danish Meteorological Institute for studies of the magnetospheric cleft region. These flights constituted a particularly harsh test of the SPS since they were conducted in full sunlight. Photoelectron contamination, principally by scattered sunlight within the instrument, had been a problem in the earlier version. The design work and laboratory testing that was carried out under this grant permitted us to use gold black surface coating that reduced the photoelectron emission sufficiently so as to completely eliminate the sun-pulses. This is shown by the Figure, which is a portion of the quick look flight record. The upper trace is the magnetic aspect signal. The lower trace is the logarithm of the electron counts per sample, the instrument sweep period being about three times the rocket spin period. The SPS collimator pointed directly at the sun once per spin, but the record shows no spurious sunpulses.

This instrument will be used again during the coming year on two rockets being instrumented by the Los Alamos Scientific Laboratory under AEC funding for further studies of the cleft in the magnetosphere. A shaped-charge barium release will be used on each flight to paint the magnetic field lines up to heights of several earth radii. This will permit studies of convection within the cleft, and evaluation of the role of the cleft as the possible source of plasma sheet particles. Our SPS will be carried on each rocket to provide in situ observations on the location and characteristics of the cleft plasma.

Another type of instrument developed with partial support under this grant is the Low Energy Electron Spectrometer (LEES). It was flown once on a Black Brant 5 rocket for auroral studies at Churchill, but unfortunately the clamshell nose cone did not come off to expose the instrument. The next flight of the same recovered payload is now scheduled for late 1975.

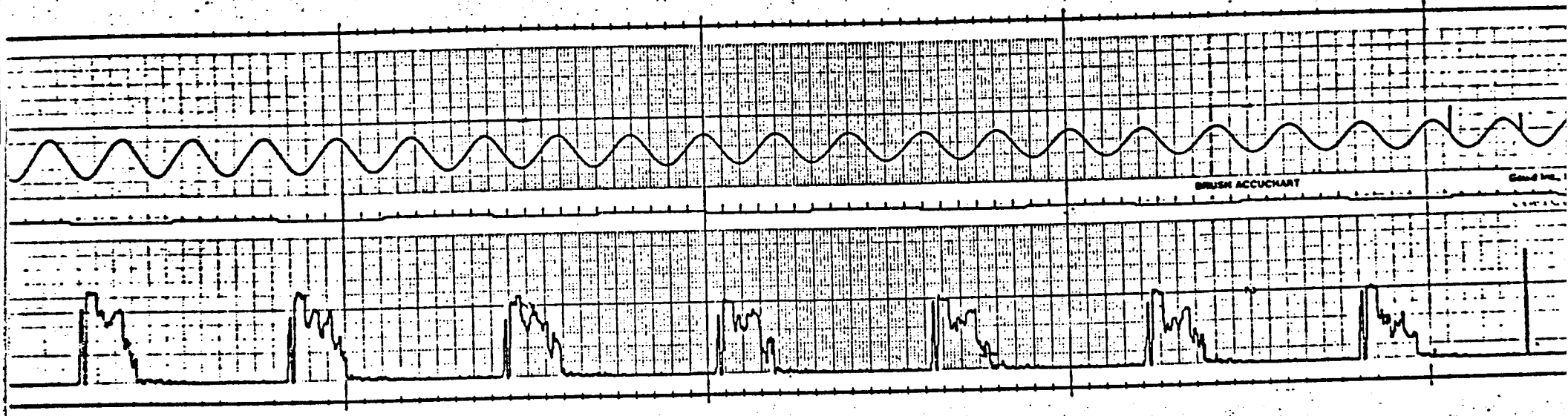

Figure 3

The aspect magnetometer (upper trace) shows the spin period of the rocket. The lower trace shows the counting rate of the soft particle spectrometer, the sweep time being about three times the spin period. No spurious counts occur with modulation at the spin frequency even though the SPS looked at the sun once per spin.

EUV LABORATORY

A. B. Christensen

An inexpensive extreme ultraviolet (EUV) laboratory has been put into operation. This facility will be used to develop rocket and satellite equipment for use in the study of upper atmospheric and space physics. It is a versatile system provided with differential pumping capabilities for windowless operation and a variety of source detectors and test chambers.

The system is built around a one-half meter Seya-Namioka vacuum monochromator. It provides a wavelength scan from 0 to 600 nm using a 600 l/mm platinum overcoated concave grating. Due to the high reflection losses, the lower wavelength of practical use is about 50 nm.

The instrument incorporated several features that reduce turnaround times and enhance its versatility. The entrance and exit slit chambers can be valved off and brought to atmospheric pressure so that sources and detectors can be replaced while maintaining high vacuum in the monochromator. A shutter has been built into the system so that the source can be operated for extended periods without danger of excessive EUV exposure of the grating surface.

The first stage of the differential pumping system is pumped with a large 150 CFM mechanical pump. The second stage is pumped with an oil ejector and a mechanical pump. This combination allows operation at 10 Torr in the source while maintaining a pressure of 7×10^{-6} Torr in the monochromator.

Both a capillary discharge source and a hollow cathode discharge source have been tested. With these sources it is possible to generate line or continuous spectra using several common laboratory gasses. The hollow cathode source appears the most stable of the two for present applications.

The exit slit is connected through an ionization chamber to an 18" diameter vacuum test chamber. It is thereby possible to measure the absolute intensity of the beam without disturbing the equipment in the test setup.

Preliminary checkout of the system has been completed. The vacuum pumping systems function according to the design specifications.

During the next few months work on the design of specific rocket instrumentation will commence. The evaluation of special electron multipliers for use in an extreme ultraviolet scanning spectrometer will be undertaken as well as an evaluation of the scattering properties of several techniques of preparing aluminum surfaces.

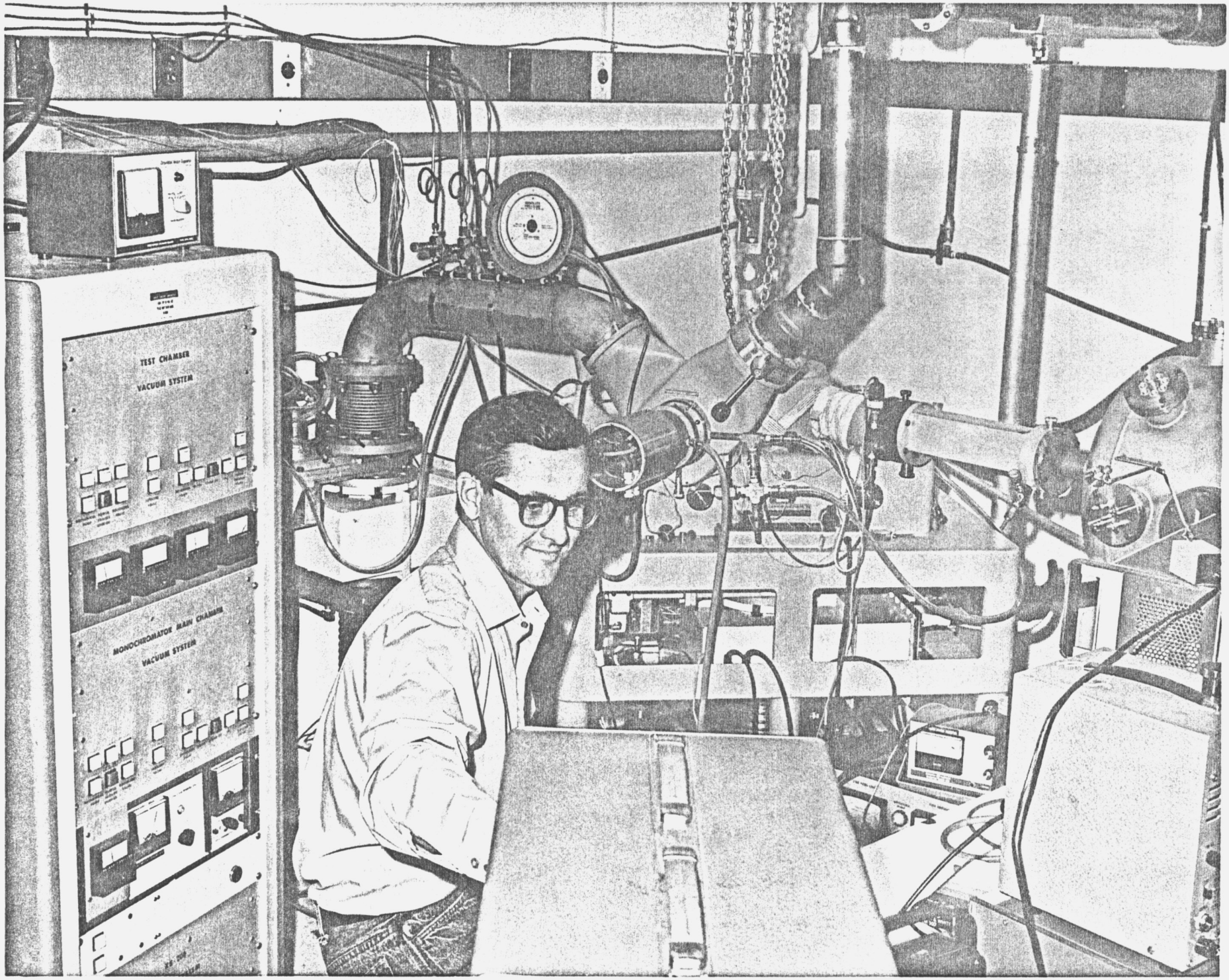
TEST CHAMBER
VACUUM SYSTEM
MONOCHROMATOR MAIN CHAMBER
VACUUM SYSTEM

Figure 4

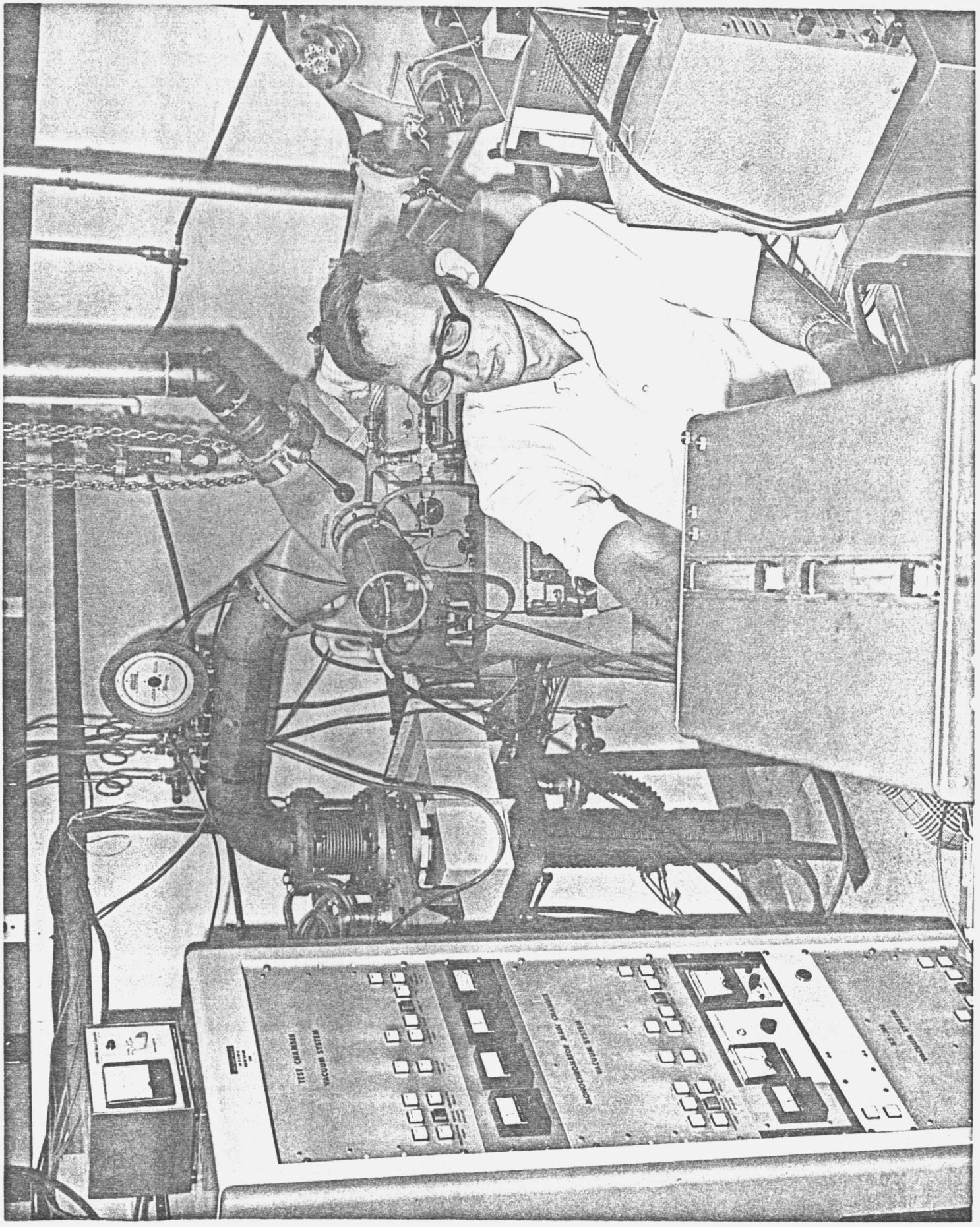
TEST CHAMBER
VACUUM SYSTEM
SUPERCONDUCTOR TEST CHAMBER
VACUUM SYSTEM

Figure 5

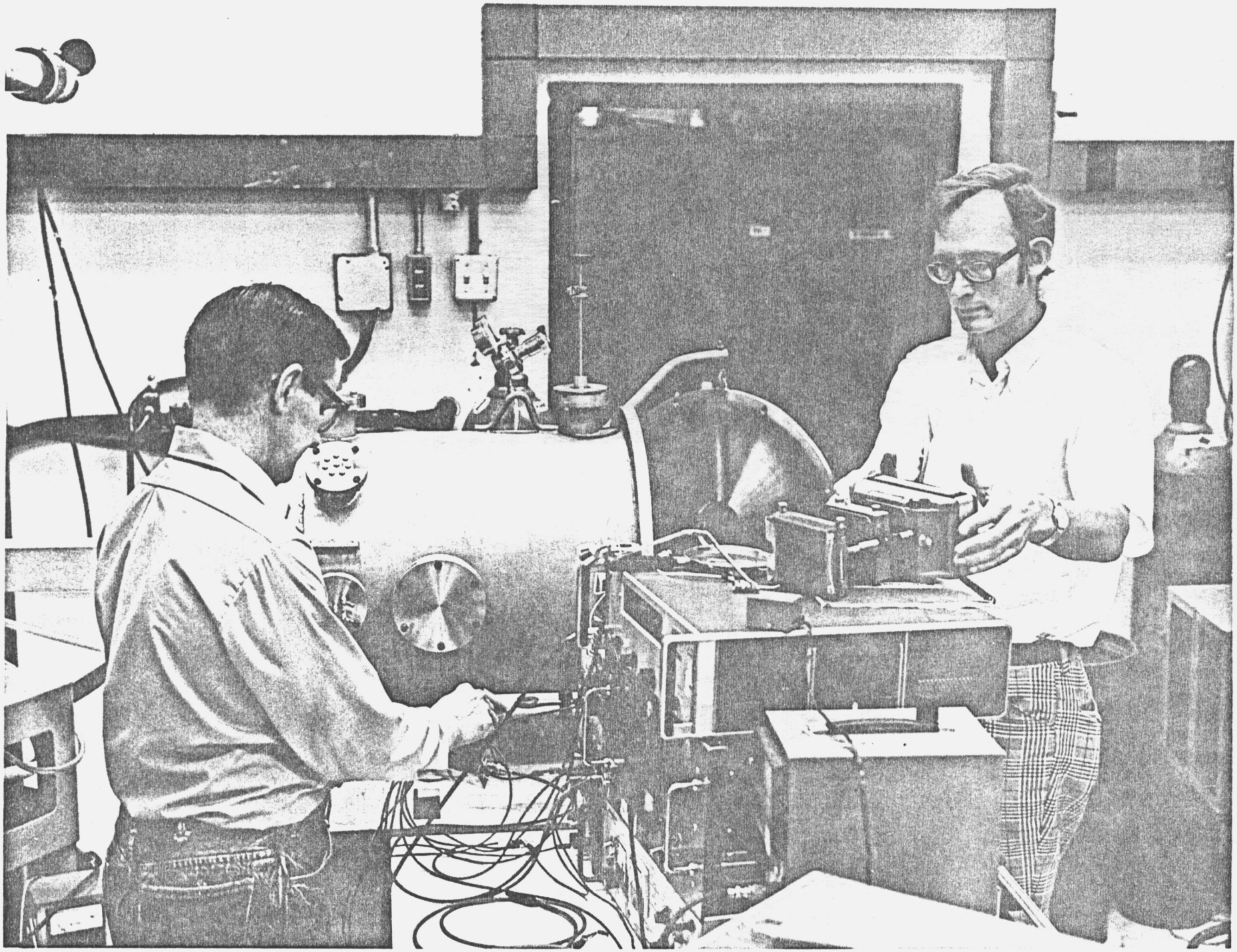

Figure 6

ISIS DATA ANALYSIS

W. J. Heikkila and J. D. Winningham

The Soft Particle Spectrometers (SPS) on the ISIS-1 and -2 satellites have provided a mountain of valuable data during the past five years. Much of this has been reduced and analyzed under project funding, but much remains to be done. Because of drastic reduction in ISIS support, we have had to curtail some activities, and support under this grant has made it possible to continue some very productive activities that we might otherwise have had to drop. This is especially true for delivery of our data to other investigators, many of whom want to correlate our observations with their own. We have sent SPS data to Gordon Rostoker (University of Alberta), L. A. Frank (University of Iowa), E. Smith (Battelle Institute), William Knudsen (Lockheed), F. Rees (University of Colorado), Ed Hones (Los Alamos), Charles Pike (AFCRL), Syun Akasofu (University of Alaska), Fumi Yasuhara (University of Alaska), Steve Mende (Lockheed), and all ISIS experimenters.

Partial support of a mini computer by this grant has greatly reduced the cost of data processing. Formerly we used a computer center with a large IBM computer for which a regular hourly rate was charged. We now use the new PDP 1145 computer which was set up with partial support from this grant. We now have our data reduction program using this new facility fully operational. The incremental cost for us now to reduce further ISIS data is minimal, and in spite of the decreased ISIS support we anticipate being able to reduce all of our data from the ISIS-2 SPS, which is still operational.

We should be able to continue this activity through to the International Magnetospheric Study, 1976-1978.

These cooperative studies with other groups are proving to be most useful and advantageous. An obvious asset is that each kind of observation can be interpreted better when it is compared with other related observations. Another advantage has been that joint projects, such as the rocket projects mentioned elsewhere in this report, have resulted. In this way we have been able to participate in several very interesting and timely undertakings.